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FILED ELECTRONICALLY VIA IBFS
Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

RE: BlackSky Global LLC; Upgrade of
Propulsion System for Global 4 Spacecraft
SAT-LOA-20180320-00023, Call Sign S3032

Dear Ms. Dortch:

BlackSky Global LLC, by its attorneys, hereby informs the Commission of an upgrade to the propulsion system to be used for its Global 4 spacecraft, the 4th satellite in its non-geostationary (NGSO) constellation from a butane-based system to water-based system.

The upgrade does not change any of the parameters or terms and conditions of its station authorization, as stated on its grant or grant conditions, nor does it increase the risk of interference to any other system. Further, with respect to the risks of orbital debris, as reflected in the attached Orbital Debris Assessment Report (ODAR), the satellite remains compliant with all NASA DAS standards. There are, moreover, improvements in key elements of that compliance showing: lowering the already low and compliant risks of collision and human casualty and reducing the orbital lifetime of the spacecraft.

As demonstrated in the attached ODAR, there would be no risk of hazardous persistent liquid droplets from the water-based system. With regard to heritage and testing, the propulsion system to be employed is based on existing propulsion systems manufactured by the same vendor, Deep Space Industries, now Bradford Space, that have been authorized by the Commission and are on-orbit today. Of the three primary components of the system, the thruster and electronics are unchanged from the existing systems on-orbit today, while the only change from existing components is an increase in the capacity of the propulsion tanks. As described in greater detail in the ODAR, to ensure that the new tanks are suitable for use in space, the entire propulsion system underwent a rigorous qualification test campaign which subjected it to environments more extreme than will exist during launch or use in space.

The improvement of the propulsion system serves the public interest, making it safer for operation in an increasingly congested orbital environment.

As the upgrade does not involve any change in the parameters or terms and conditions of BlackSky's station authorization, does not pose an interference threat to any other system, is NASA DAS compliant, and, taking into account newly proposed standards, does not pose any threat of the release of hazardous persistent liquids, BlackSky considers the change as *de minimis* , which does not require a modification application under Section 25.117(a) of the Commission's rules.

Please direct any questions to the undersigned.

Respectfully submitted,

Henry Goldberg

Henry Goldberg
Jonathan L. Wiener
Attorneys for BlackSky Global LLC

BlackSky Global
Global-4 Satellite
Orbital Debris Assessment Report (ODAR) – Annotated

This report is presented in compliance with NASA-STD-8719.14, APPENDIX A.

Report Version: B(R1), February 13, 2019

Revision history:

Version	**Date**	**Author**	**Description**
B(R) – Annotated	02/08/2019	Miles Atherly, Katie Todd	Updated to reflect Global-4 propulsion system change. Highlighted additional updates in the document referencing the new propulsion system.
B(R1) Annotated	02/13/2019	Kevin Brown, Kristina Hloptsidis	Updated to add additional detail regarding propulsion system and heritage

Document Data is Not Restricted.

This document contains no proprietary, ITAR, or export controlled information.

DAS Software Version Used In Analysis: v2.0.2

DAS Solar flux file Used: Released 31 October 2018

Table Contents

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Self-assessment of the ODAR using the format in Appendix A.2 of NASA-STD- 8719.14:

A self-assessment is provided below in accordance with the assessment format provided in Appendix A.2 of NASA-STD-8719.14.

Orbital Debris Self-Assessment Report Evaluation: Global-4 Satellite

Requirement #	Launch Vehicle				Spacecraft			Comments
	Compliant	Not Compliant	Incomplete	Standard Non-Compliant	Compliant or N/A	Not Compliant	Incomplete	
4.3-1.a	☐	☐	☐	☐	☒	☐	☐	No Debris Released in LEO.
4.3-1.b	☐	☐	☐	☐	☒	☐	☐	No Debris Released in LEO.
4.3-2	☐	☐	☐	☐	☒	☐	☐	No Debris Released in GEO.
4.4-1	☐	☐	☐	☐	☒	☐	☐	Not applicable.
4.4-2	☐	☐	☐	☐	☒	☐	☐	Propulsion tank containing water will be depleted during operations
4.4-3	☐	☐	☐	☐	☒	☐	☐	No planned breakups.
4.4-4	☐	☐	☐	☐	☒	☐	☐	No planned breakups.
4.5-1	☐	☐	☐	☐	☒	☐	☐	Collision probability 0.000001
4.5-2	☐	☐	☐	☐	☒	☐	☐	Not applicable.
4.6-1(a)	☐	☐	☐	☐	☒	☐	☐	Natural forces cause atmospheric reentry
4.6-1(b)	☐	☐	☐	☐	☒	☐	☐	Not applicable.
4.6-1(c)	☐	☐	☐	☐	☒	☐	☐	Not applicable.
4.6-2	☐	☐	☐	☐	☒	☐	☐	Spacecraft does not go to GEO.
4.6-3	☐	☐	☐	☐	☒	☐	☐	Spacecraft does not go beyond LEO.
4.6-4	☐	☐	☐	☐	☒	☐	☐	Requirements 4.6-1 through 4.6-3 are met
4.7-1	☐	☐	☐	☐	☒	☐	☐	DAS reports human casualty probability < 1:10,000
4.8-1					☒	☐	☐	No tethers used.

Summary of Changes:

Changes stem from propulsion system update described in Mission Overview

Comments in Self-Assessment updated – pg 4

Windchill link updated - pg 5

Schedule and Mission Overview updated – pg 5.

Launch vehicle and constellation deployment updated – pg 6

Satellite mass updated – pg 6-7

Propulsion and pressurant system updated – pg 7

Large Object Impact and Debris Generation Probability updated – pg 13

Area-to-mass ratio updated – pg 14

Mission lifetime updated – pg 14-15

Altitude profile update – pg 16-17

Risk of Human Casualty – pg 18

DAS Output update – pg 19-38

Assessment Report Format:

ODAR Technical Sections Format Requirements:

BlackSky Global LLC ("BlackSky") is a U.S. company; this ODAR, for BlackSky's Global-4 satellite, follows the format recommended in NASA- STD-8719.14, Appendix A.1 and includes the content indicated at a minimum in each section 2 through 8 below. Sections 9 through 14 apply to the launch vehicles ODAR and are not covered here.

All files created from the DAS 2.0.2 software and calculation files are located on windchill.

Windchill Link (This is a BlackSky internal reference)

ODAR Section 1: Program Management and Mission Overview

Project Manager: Katie Todd

Foreign government or space agency participation: none

Schedule of upcoming mission milestones:

Satellite	Flight Readiness Review	Launch
Global-4	1 month prior to launch	April 2019

Table 1: Mission Milestones

Mission Overview:
Global-1, 2, 3, and 4 are commercial Earth observation satellites. These are the first of many satellites planned for BlackSky's earth-observing constellation. This ODAR covers the Global-4 satellite only as it has had a design change. The design change on Global-4 consists of the removal of the butane-based propulsion system and a replacement with a water-based propulsion system. The new water-based system offers better propulsion

capability and easier range safety compliance than the previous system. All other aspects of the satellite design impacting the debris assessment are unchanged or improved from the Global-1 through Global-3 design. The new system offers improved performance, which, coupled with the orbital parameters of the mission, reduces the probability of collision and human casualty. There is also a reduction in post-operation lifetime. The design files and DAS inputs were updated for the Global-4 design update, and the results of the DAS assessments are presented in this report.

The Global-4 propulsion system propellant is liquid water and the pressurant is two-phase (both liquid and vapor) FE-36. There would be no risk of hazardous persistent liquid droplets. The liquid water propellant has a low but non-zero vapor-pressure. When liquid water is exposed to vacuum it will immediately evaporate and form small ice crystals. Once the ice crystals are exposed to sunlight they will sublimate into vapor and disperse, therefore no droplets will remain. This is observed on the space station when they occasionally eject waste water. The FE-36 pressurant has a relatively high vapor-pressure (39.5 psia at 25degC) and a freezing point of -103degC. Therefore it will evaporate rapidly when exposed to vacuum and it will not form droplets.

The Global-4 propulsion system is a derivative of existing propulsion systems manufactured by the same vendor, Deep Space Industries, now Bradford Space, that have been authorized by the Commission and are on-orbit today.[1] The propulsion system was modified from existing systems to increase the capacity of the propellant tanks. The thruster and electronics are unchanged from the existing systems on-orbit today. To ensure that the new tanks are suitable for use in space, the entire propulsion system underwent a rigorous qualification test campaign which subjected it to environments more extreme than it will see during launch or use in space. The testing included extreme vibration, quasi-static (g-loading), and thermal environments. In addition to these environments, the new tanks were also destructively burst-tested to demonstrate that they have much more strength than required to contain the propellant and pressurant. The propulsion system passed all of these tests and has been qualified for use in space.

Global-4 is launching in early 2019 (see table 1 above). Global-4 will be launched into a 45-degree orbit, with more detail shown in Table 3 below. The planned mission duration is for each Global satellite is 36 months (3 years). At the end of its mission, the satellite will release any remaining propellant (which is expected to be depleted during operations) and rely on atmospheric drag to fully deorbit the spacecraft.

ODAR Summary: No debris released in normal operations; no credible scenario for breakups; the collision probability with other objects is compliant with NASA standards; and the estimated nominal decay lifetime due to atmospheric drag is under 25 years following operations (max is 7.04 years including 3 years of operations, as calculated by DAS 2.0.2).

[1] See, HawkEye 360, Inc. application for experimental license to construct and operate an NGSO satellite, Callsign WI2XWX, FCC File No. 0024-EX-CN-2017, Exhibit 3 ODAR, p. 5 (description of propulsion system) and Exhibit 2 (Technical Information), pages 1 and 6.

Launch vehicles and launch sites:

Project	Launch Vehicle	Launch location
Global-4	Rocket Lab Electron	Mahia Peninsula, New Zealand

Table 2: Launch Vehicles and Launch Sites

Mission duration: Maximum Nominal Operations: 36 months (3 years)

Post-Operations Orbit lifetime: See table 5 in section 6.4

Constellation Launch and deployment profile:

Project	Altitude	Inclination	LTDN or LTAN	Comments
Global-4	475 km circular	45°	Not applicable	RAAN will vary over time; precessing orbit

Table 3: Orbit profiles

ODAR Section 2: Spacecraft Description

Physical description of the spacecraft:

Global-4 has a launch mass of 55.6 kg (fly away mass). Basic physical dimensions are 55 cm x 67 cm x 86 cm. A CAD model of the spacecraft is shown in Figure 1

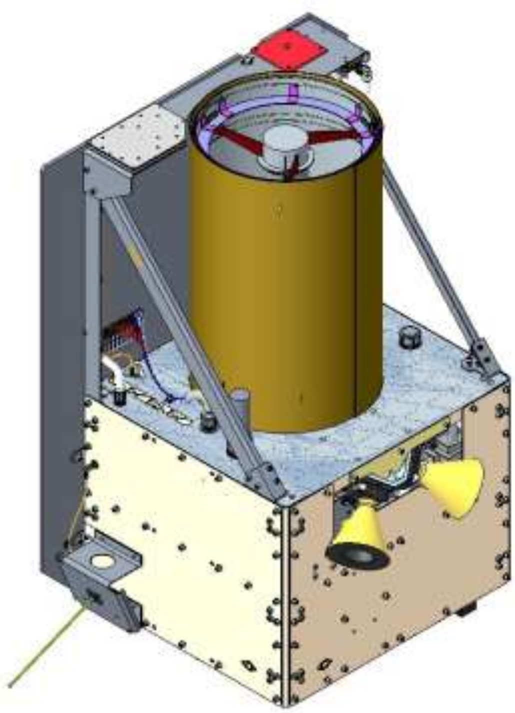

Figure 1. CAD model of the Global-4 spacecraft.

Each Global satellite's load bearing structure is comprised of three 45 cm x 50 cm skeleton deck plates, radiating side plates, and a vertical mounted 66.5cm x 86 cm side solar panel connected with struts. The Global satellites maintain 3-axis attitude control. Attitude knowledge is provided primarily by two orthogonally mounted star trackers. Attitude actuators include four reaction wheels and three orthogonal magnetorquers.

Total satellite mass at launch, including all propellants and fluids: 55.6 kg.

Dry mass of satellites at launch, excluding all propellant and pressurants: 51.1kg

Description of all propulsion systems (cold gas, mono-propellant, bi-propellant, electric, nuclear):

Global-4 contains a single propulsion system with a single thruster.

This system uses electrically warmed distilled water as the working fluid and FE-36 as the pressurant. The water is warmed to several hundred degrees Celsius via an electrically heated superheater just before exiting the nozzle. Propulsion is not required to deorbit the satellite, but is part of the satellite to allow for orbit phasing and minor orbit adjustments.

Identification, including mass and pressure, of all fluids (liquids and gases) planned to be on board and a description of the fluid loading plan or strategies, excluding fluids in sealed heat pipes: 4.4 kg of water and 146g of FE-36 at maximum expected operating pressure (MEOP) of 63.5 psia. Fluid is loaded through independent, electrically actuated fill and drain valves.

Fluids in Pressurized Batteries: None. Each Global sat uses two unpressurized standard COTS Lithium-Ion batteries. Each battery has a height of 98mm, a width of 96mm, a length of 176mm, and a mass of 1.6 kg.

Description of attitude control system and indication of the normal attitude of the spacecraft with respect to the velocity vector:

The long axis of the spacecraft can be oriented parallel to the nadir vector during imaging, but the satellite will typically be oriented in a sun-pointing attitude. For the purposes of orbital debris assessment, the smallest (worst-case for orbital lifetime) cross-sectional area is used, meaning that a face of 55 x 55 cm is in the velocity direction (the actual area of the deck plates are 45 x 50 cm, but there are some protrusions from the plates, such as the star trackers, so 55 x 55 cm is used). This results in a cross-section area of $0.3025 m^2$. The cross sectional area in a nadir-pointing configuration would be between $0.47\ m^2$ and $0.57\ m^2$.

Description of any range safety or other pyrotechnic devices: No pyrotechnic devices are used.

Description of the electrical generation and storage system: Standard COTS Lithium-Ion battery cells are charged before payload integration and provide electrical energy during the mission. The cells are recharged by solar cells mounted on the solar arrays. The battery cell protection circuit manages the charging cycle.

Identification of any other sources of stored energy not noted above: None.

Identification of any radioactive materials on board: None**.**

ODAR Section 3: Assessment of Spacecraft Debris Released during Normal Operations

Identification of any object (>1 mm) expected to be released from the spacecraft any time after launch, including object dimensions, mass, and material: There are no intentional releases.

Rationale/necessity for release of each object: N/A.

Time of release of each object, relative to launch time: N/A.

Release velocity of each object with respect to spacecraft: N/A.

Expected orbital parameters (apogee, perigee, and inclination) of each object after release: N/A.

Calculated orbital lifetime of each object, including time spent in Low Earth Orbit (LEO): N/A.

Assessment of spacecraft compliance with Requirements 4.3-1 and 4.3-2 (per DAS v2.0.2)

4.3-1, Mission Related Debris Passing Through LEO: COMPLIANT

4.3-2, Mission Related Debris Passing Near GEO: COMPLIANT

ODAR Section 4: Assessment of Spacecraft Intentional Breakups and Potential for Explosions.

Potential causes of spacecraft breakup during deployment and mission operations:

There is no credible scenario that would result in spacecraft breakup during normal deployment and operations.

Summary of failure modes and effects analyses of all credible failure modes which may lead to an accidental explosion:

In-mission failure of a battery cell protection circuit could lead to a short circuit resulting in overheating and a very remote possibility of battery cell explosion. The battery safety systems discussed in the FMEA (see requirement 4.4-1 below) describe the combined faults that must occur for any of seven (7) independent, mutually exclusive failure modes to lead to explosion.

In addition to the battery protection mentioned about, the Global-4 battery unit features two temperature sensors which monitor battery cells for high temperatures.

Detailed plan for any designed spacecraft breakup, including explosions and intentional collisions:

There are no planned breakups.

List of components which shall be passivated at End of Mission (EOM) including method

of passivation and amount which cannot be passivated:

It is expected that all propellant (water) in the propulsion system will be consumed by EOM. In the event that it is not, it will be released (used to lower the orbit as much as possible) before EOM. After release of water at EOM, all pressurant will be exhausted through the fill/drain valve. In the event of a system failure that prevents release of all propellant, it has no detrimental impact; the orbital lifetime predictions assume the worst-case scenario that propulsion is not used to lower the orbit, and the water and pressurant do not pose a risk if not passivated.

Rationale for all items which are required to be passivated, but cannot be due to their design:

Global satellites battery charge circuits include overcharge protection and a parallel design to limit the risk of battery failure. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

Assessment of spacecraft compliance with Requirements 4.4-1 through 4.4-4:

Requirement 4.4-1**:** Limiting the risk to other space systems from accidental explosions during deployment and mission operations while in orbit about Earth or the Moon:

For each spacecraft and launch vehicle orbital stage employed for a mission, the program or project shall demonstrate, via failure mode and effects analyses or equivalent analyses, that the integrated probability of explosion for all credible failure modes of each spacecraft and launch vehicle is less than 0.001 (excluding small particle impacts) (Requirement 56449).

Compliance statement:

Required Probability: 0.001.
Expected probability: 0.000.

Supporting Rationale and FMEA details:

Battery explosion:

Effect: All failure modes below might theoretically result in battery explosion with the possibility of orbital debris generation. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of the selected COTS batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.
Probability: Extremely Low. It is believed to be a much less than 0.1% probability that multiple independent (not common mode) faults must occur for each failure mode to cause the ultimate effect (explosion).

Failure mode 1: Internal short circuit.

Mitigation 1: Qualification and acceptance shock, vibration, thermal cycling, and vacuum tests followed by maximum system rate-limited charge and discharge to prove that no internal short circuit sensitivity exists.

Combined faults required for realized failure: Environmental testing **AND** functional charge/discharge tests must both be ineffective in discovery of the failure mode.

Failure Mode 2: Internal thermal rise due to high load discharge rate.

*Combined faults required for realized failure: S*pacecraft thermal design must be incorrect **AND** external over-current detection and disconnect function must fail to enable this failure mode.

Failure Mode 3: Excessive discharge rate or short circuit due to external device failure or terminal contact with conductors not at battery voltage levels (due to abrasion or inadequate proximity separation).

Mitigation 3: This failure mode is negated by a) qualification-tested short circuit protection on each external circuit, b) design of battery packs and insulators such that no contact with nearby board traces is possible without being caused by some other mechanical failure, c) obviation of such other mechanical failures by proto-qualification and acceptance environmental tests (shock, vibration, thermal cycling, and thermal-vacuum tests).

Combined faults required for realized failure: An external load must fail/short-circuit **AND** external over-current detection and disconnect function failure must all occur to enable this failure mode.

Failure Mode 4: Inoperable vents.

Mitigation 4: Battery vents are not inhibited by the battery holder design or the spacecraft.

Combined effects required for realized failure: The final assembler fails to install proper venting.

Failure Mode 5: Crushing.

Mitigation 5: This mode is negated by spacecraft design. There are no moving parts in the proximity of the batteries.

Combined faults required for realized failure: A catastrophic failure must occur in an external system **AND** the failure must cause a collision sufficient to crush the batteries leading to an internal short circuit **AND** the satellite must be in a naturally sustained orbit at the time the crushing occurs.

Failure Mode 6: Low level current leakage or short-circuit through battery pack case or due to moisture-based degradation of insulators.

Mitigation 6: These modes are negated by a) battery holder/case design made of non-conductive plastic, and b) operation in vacuum such that no moisture can affect insulators.

Combined faults required for realized failure: Abrasion or piercing failure of circuit board coating or wire insulators **AND** dislocation of battery packs **AND** failure of battery terminal insulators **AND** failure to detect such failure modes in environmental tests must occur to result in this failure mode.

Failure Mode 7: Excess temperatures due to orbital environment and high discharge combined.

Mitigation 7: The spacecraft thermal design will negate this possibility. Thermal rise has been analyzed in combination with space environment temperatures showing that batteries do not exceed normal allowable operating temperatures which are well below temperatures of concern for explosions.

Combined faults required for realized failure: Thermal analysis **AND** thermal design **AND** mission simulations in thermal-vacuum chamber testing **AND** over-current monitoring and control must all fail for this failure mode to occur.

Requirement 4.4-2: Design for passivation after completion of mission operations while in orbit about Earth or the Moon:

Design of all spacecraft and launch vehicle orbital stages shall include the ability to deplete all onboard sources of stored energy and disconnect all energy generation sources when they are no longer required for mission operations or postmission disposal or control to a level which cannot cause an explosion or deflagration large enough to release orbital debris or break up the spacecraft (Requirement 56450).

Compliance statement:

Global battery charge circuits include overcharge protection and a parallel design to limit the risk of battery failure. However, in the unlikely event that a battery cell does explosively rupture, the small size, mass, and potential energy, of these small batteries is such that while the spacecraft could be expected to vent gases, most debris from the battery rupture should be contained within the vessel due to the lack of penetration energy.

Requirement 4.4-3. Limiting the long-term risk to other space systems from planned breakups:

Compliance statement:
This requirement is not applicable. There are no planned breakups.

Requirement 4.4-4: Limiting the short-term risk to other space systems from planned breakups:

Compliance statement:
This requirement is not applicable. There are no planned breakups.

ODAR Section 5: Assessment of Spacecraft Potential for On-Orbit Collisions

Assessment of spacecraft compliance with Requirements 4.5-1 and 4.5-2 (per DAS v2.0.2, and calculation methods provided in NASA-STD-8719.14, section 4.5.4):

Requirement 4.5-1: Limiting debris generated by collisions with large objects when operating in Earth orbit:
For each spacecraft and launch vehicle orbital stage in or passing through LEO, the program or project shall demonstrate that, during the orbital lifetime of each spacecraft and orbital stage, the probability of accidental collision with space objects larger than 10 cm in diameter is less than 0.001 (Requirement 56506).

Large Object Impact and Debris Generation Probability:

Satellite	Collision Probability	Compliance status
Global-4	0.000001	COMPLIANT

Table 4: Large Debris Generation

Requirement 4.5-2: Limiting debris generated by collisions with small objects when operating in Earth or lunar orbit**:**
For each spacecraft, the program or project shall demonstrate that, during the mission of the spacecraft, the probability of accidental collision with orbital debris and meteoroids sufficient to prevent compliance with the applicable postmission disposal requirements is less than 0.01 (Requirement 56507).

Small Object Impact and Debris Generation Probability:
Collision Probability: not applicable; COMPLIANT.

The satellite orbits decay naturally; no propulsion is required for post-mission disposal. Thus there are no parts of the satellite that are critical to be in compliance with post-mission disposal requirements.

Identification of all systems or components required to accomplish any postmission disposal operation, including passivation and maneuvering:
No systems or components are required. The orbit for Global-4 naturally decays with no maneuvering required.

ODAR Section 6: Assessment of Spacecraft Post-mission Disposal Plans and Procedures

6.1 Description of spacecraft disposal option selected: After completing its planned operations, the satellites will deorbit naturally by atmospheric re-entry. At the end of each of the Global satellite's operational life (i.e. at EOM) the attitude control system will stop counteracting the aerodynamic disturbance torques. This will result in the satellite gradually assuming a dynamically stable configuration. For atmospheric drag / re-entry calculations in DAS, the minimum plausible cross-section drag area of 55 x 55 cm was assumed. This is conservative because it represents the minimum cross section possible and ignores the fact that the satellite may be in other orientations after the end of the mission.

6.2 Plan for any spacecraft maneuvers required to accomplish postmission disposal:

No maneuvers are required following normal operations.

6.3 Calculation of area-to-mass ratio after postmission disposal, if the controlled reentry option is not selected:

Spacecraft Mass (EOL): 51.0 kg

Cross-sectional Area: 0.3025 m^2

Area to mass ratio: 0.0059 m^2/kg

6.4 Assessment of spacecraft compliance with Requirements 4.6-1 through 4.6-5 (per DAS v 2.0.2 and NASA-STD-8719.14 section):

Requirement 4.6-1: Disposal for space structures passing through LEO:
A spacecraft or orbital stage with a perigee altitude below 2000 km shall be disposed of by one of three methods:
(Requirement 56557)
a. Atmospheric reentry option:

- *Leave the space structure in an orbit in which natural forces will lead to atmospheric reentry within 25 years after the completion of mission but no more than 30 years after launch; or*
- *Maneuver the space structure into a controlled de-orbit trajectory as soon as practical after completion of mission.*

b. Storage orbit option: Maneuver the space structure into an orbit with perigee altitude greater than 2000 km and apogee less than GEO - 500 km.
c. Direct retrieval: Retrieve the space structure and remove it from orbit within 10 years after

completion of mission.

The analysis of this requirement for each satellite is shown below.

Satellite Name	Operational Orbit	Post-ops Life	Total Lifetime
Global-4	475 km circular	4.04 years	7.04 years

Table 5: Lifetimes

Altitude history versus time was analyzed for Global-4 and is shown on the following page. Figure 2 shows the altitude of the satellite assuming no propulsion system is used to maintain the altitude, and the orbit decay begins immediate after launch in April 2019. Figure 3 shows the altitude of the satellite assuming propulsion is used to maintain the orbit at 450 km for 3 years during the operating life of the satellite. Following this, the satellite orbit is assumed to decay from drag, starting at an altitude of 450 km in April 2022.

Global-4 Altitude history over time – no propulsion:

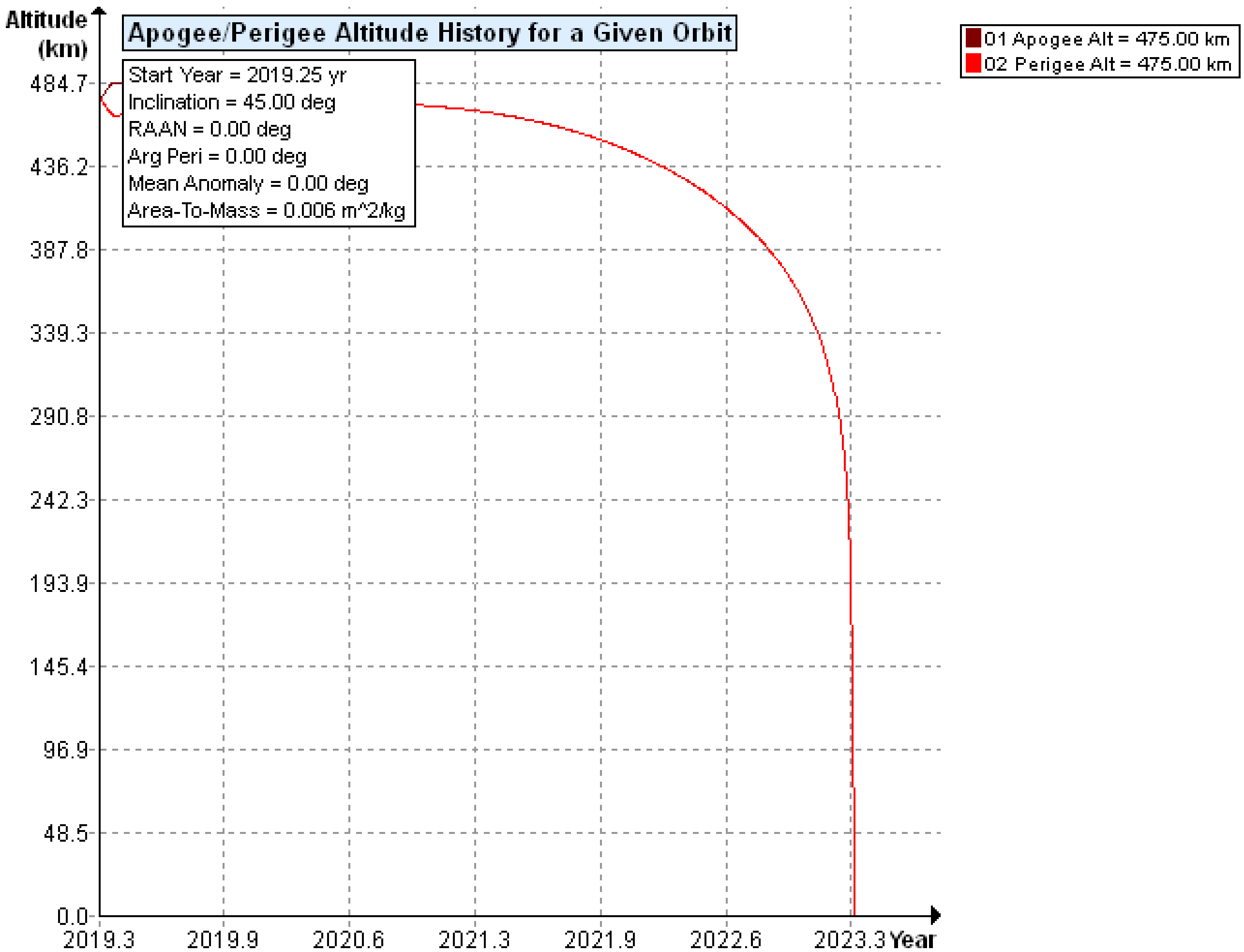

Figure 2: Global-4 Apogee/Perigee Altitude History for a Given Orbit – No propulsion

Analysis: The Global-4 satellite reentry is COMPLIANT using method "a: Atmospheric reentry option".

Global-4 Altitude history over time – propulsion used:

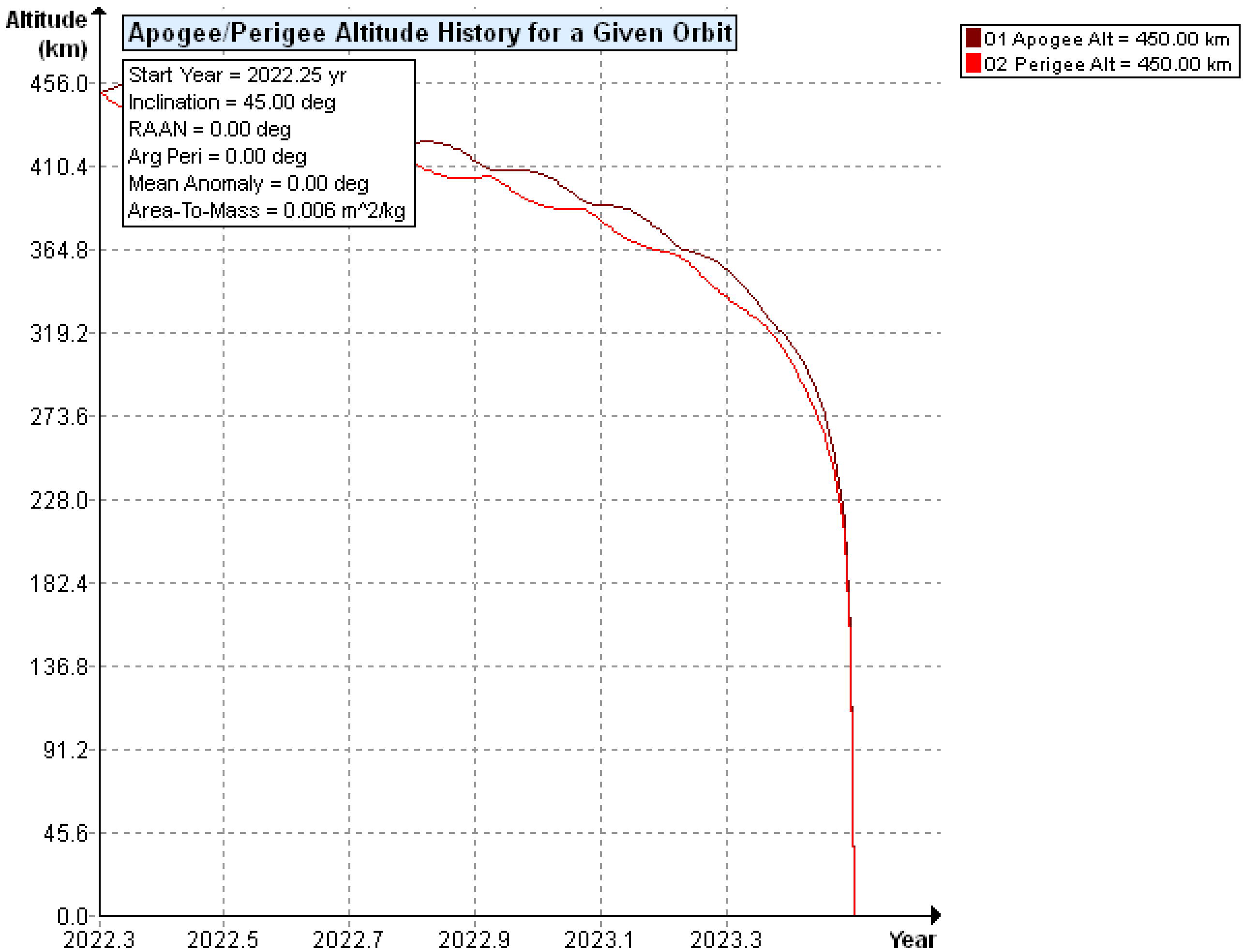

Figure 3: Global-4 Apogee/Perigee Altitude History for a Given Orbit – Propulsion used to maintain orbit at 450 km for 3 years

Analysis: The Global-4 satellite reentry is COMPLIANT using method "a: Atmospheric reentry option".

Requirement 4.6-2. Disposal for space structures near GEO.

Analysis: Not applicable.

Requirement 4.6-3. Disposal for space structures between LEO and GEO.

Analysis: Not applicable.

Requirement 4.6-4. Reliability of Postmission Disposal Operations

Analysis: The minimum drag configuration is the aerodynamically stable state, and provides the worst-case re-entry time. This minimum drag configuration was assumed for atmospheric re-entry analysis.

ODAR Section 7: Assessment of Spacecraft Reentry Hazards

Assessment of spacecraft compliance with Requirement 4.7-1:

Requirement 4.7-1: Limit the risk of human casualty:
The potential for human casualty is assumed for any object with an impacting kinetic energy in excess of 15 joules:
a) For uncontrolled reentry, the risk of human casualty from surviving debris shall not exceed 0.0001 (1:10,000) (Requirement 56626).

Summary Analysis Results:

DAS v2.0.2 reports that each Global satellite is compliant with the requirement. The total risk of human casualty for the spacecraft is given in the table below. According to DAS calculations, there is a low probability that some spacecraft components may reach the ground (see DAS input data below for input parameters). However, the DAS software does not currently allow explicit modeling of the specific geometries for these components, so these numbers are expected to be larger than anticipated due to conservatism in the inputs provided to DAS.

Satellite	**Risk of Human Casualty**	**Compliance status**
Global-4	1:13,200	COMPLIANT

Table 6. Casualty risk from re-entry debris.

Below is a full output from the DAS software for Global-4

Analysis (per DAS v2.0.2):

11 29 2018; 22:11:12PM DAS Application Started
11 29 2018; 22:11:12PM Opened Project C:\Users\rdeb\AppData\Local\NASA\DAS 2.0\project\Global-4 Propulsion Update Nov 2018\
11 29 2018; 22:11:59PM Opened Project C:\Users\rdeb\AppData\Local\NASA\DAS 2.0\project\Global-4 Propulsion Update Nov 2018\
11 29 2018; 22:12:21PM Processing Requirement 4.3-1: Return Status : Not Run

====================
No Project Data Available
====================

=============== End of Requirement 4.3-1 ===============
11 29 2018; 22:12:24PM Processing Requirement 4.3-2: Return Status : Passed

====================
No Project Data Available
====================

=============== End of Requirement 4.3-2 ===============
11 29 2018; 22:12:27PM Requirement 4.4-3: Compliant

=============== End of Requirement 4.4-3 ===============
11 29 2018; 22:12:34PM Processing Requirement 4.5-1: Return Status : Passed

==============
Run Data
==============

INPUT

Space Structure Name = Global-4
Space Structure Type = Payload
Perigee Altitude = 475.000000 (km)
Apogee Altitude = 475.000000 (km)
Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass Ratio = 0.005900 (m^2/kg)
Start Year = 2019.250000 (yr)
Initial Mass = 55.400000 (kg)
Final Mass = 51.000000 (kg)
Duration = 3.000000 (yr)
Station-Kept = False
Abandoned = True
PMD Perigee Altitude = -1.000000 (km)
PMD Apogee Altitude = -1.000000 (km)

PMD Inclination = 0.000000 (deg)
PMD RAAN = 0.000000 (deg)
PMD Argument of Perigee = 0.000000 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Collision Probability = 0.000001
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range
Status = Pass

==============

=============== End of Requirement 4.5-1 ===============
11 29 2018; 22:17:43PM   Requirement 4.5-2: Compliant

==
Spacecraft = Global-4
Critical Surface = FC+X
==

INPUT

Apogee Altitude = 475.000000 (km)
Perigee Altitude = 475.000000 (km)
Orbital Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass = 0.005900 (m^2/kg)
Initial Mass = 51.000000 (kg)
Final Mass = 51.000000 (kg)
Station Kept = No
Start Year = 2019.250000 (yr)
Duration = 3.000000 (yr)
Orientation = Random Tumbling
CS Areal Density = 15.624019 (g/cm^2)
CS Surface Area = 0.025474 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 0.427403 (g/cm^2) Separation: 6.990000 (cm)

OUTPUT

Probabilty of Penitration = 0.000000
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

==
Spacecraft = Global-4
Critical Surface = FC+Y

===

INPUT

Apogee Altitude = 475.000000 (km)
Perigee Altitude = 475.000000 (km)
Orbital Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass = 0.005900 (m^2/kg)
Initial Mass = 51.000000 (kg)
Final Mass = 51.000000 (kg)
Station Kept = No
Start Year = 2019.250000 (yr)
Duration = 3.000000 (yr)
Orientation = Random Tumbling
CS Areal Density = 28.141687 (g/cm^2)
CS Surface Area = 0.014143 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1 Density: 0.383772 (g/cm^2) Separation: 5.080000 (cm)

OUTPUT

Probabilty of Penitration = 0.000000
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Global-4
Critical Surface = Battery+X
===

INPUT

Apogee Altitude = 475.000000 (km)
Perigee Altitude = 475.000000 (km)
Orbital Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass = 0.005900 (m^2/kg)
Initial Mass = 51.000000 (kg)
Final Mass = 51.000000 (kg)
Station Kept = No
Start Year = 2019.250000 (yr)
Duration = 3.000000 (yr)
Orientation = Random Tumbling
CS Areal Density = 9.469697 (g/cm^2)
CS Surface Area = 0.016896 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))

CS Pressurized = No
Outer Wall 1   Density: 0.427403 (g/cm^2) Separation: 1.790000 (cm)

OUTPUT

Probabilty of Penitration = 0.000000
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Global-4
Critical Surface = Battery+Y
===

INPUT

Apogee Altitude = 475.000000 (km)
Perigee Altitude = 475.000000 (km)
Orbital Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass = 0.005900 (m^2/kg)
Initial Mass = 51.000000 (kg)
Final Mass = 51.000000 (kg)
Station Kept = No
Start Year = 2019.250000 (yr)
Duration = 3.000000 (yr)
Orientation = Random Tumbling
CS Areal Density = 17.006803 (g/cm^2)
CS Surface Area = 0.009408 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = No
Outer Wall 1   Density: 0.383772 (g/cm^2) Separation: 2.800000 (cm)

OUTPUT

Probabilty of Penitration = 0.000000
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Global-4
Critical Surface = Tank+Y
===

INPUT

Apogee Altitude = 475.000000 (km)
Perigee Altitude = 475.000000 (km)
Orbital Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass = 0.005900 (m^2/kg)
Initial Mass = 51.000000 (kg)
Final Mass = 51.000000 (kg)
Station Kept = No
Start Year = 2019.250000 (yr)
Duration = 3.000000 (yr)
Orientation = Random Tumbling
CS Areal Density = 3.952611 (g/cm^2)
CS Surface Area = 0.016926 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = Yes
Outer Wall 1   Density: 0.676247 (g/cm^2) Separation: 9.320000 (cm)

OUTPUT

Probabilty of Penitration = 0.000001
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

===
Spacecraft = Global-4
Critical Surface = Tank+X
===

INPUT

Apogee Altitude = 475.000000 (km)
Perigee Altitude = 475.000000 (km)
Orbital Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Final Area-To-Mass = 0.005900 (m^2/kg)
Initial Mass = 51.000000 (kg)
Final Mass = 51.000000 (kg)
Station Kept = No
Start Year = 2019.250000 (yr)
Duration = 3.000000 (yr)
Orientation = Random Tumbling
CS Areal Density = 1.091093 (g/cm^2)
CS Surface Area = 0.061315 (m^2)
Vector = (0.000000 (u), 0.000000 (v), 0.000000 (w))
CS Pressurized = Yes
Outer Wall 1   Density: 0.427403 (g/cm^2) Separation: 4.730000 (cm)

OUTPUT

Probabilty of Penitration = 0.000107
Returned Error Message: Normal Processing
Date Range Error Message: Normal Date Range

11 29 2018; 22:17:55PM Processing Requirement 4.6 Return Status : Passed

==============
Project Data
==============

INPUT

Space Structure Name = Global-4
Space Structure Type = Payload

Perigee Altitude = 475.000000 (km)
Apogee Altitude = 475.000000 (km)
Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.005900 (m^2/kg)
Start Year = 2019.250000 (yr)
Initial Mass = 55.400000 (kg)
Final Mass = 51.000000 (kg)
Duration = 3.000000 (yr)
Station Kept = False
Abandoned = True
PMD Perigee Altitude = 440.704423 (km)
PMD Apogee Altitude = 440.704423 (km)
PMD Inclination = 44.994543 (deg)
PMD RAAN = 82.203108 (deg)
PMD Argument of Perigee = 204.147630 (deg)
PMD Mean Anomaly = 0.000000 (deg)

OUTPUT

Suggested Perigee Altitude = 440.704423 (km)
Suggested Apogee Altitude = 440.704423 (km)
Returned Error Message = Passes LEO reentry orbit criteria.

Released Year = 2023 (yr)
Requirement = 61
Compliance Status = Pass

==============

============== End of Requirement 4.6 ==============
11 29 2018; 22:18:21PM *********Processing Requirement 4.7-1
Return Status : Passed

***********INPUT****
Item Number = 1

name = Global-4
quantity = 1
parent = 0
materialID = 5
type = Box
Aero Mass = 51.000000
Thermal Mass = 51.000000
Diameter/Width = 0.500000
Length = 0.845000
Height = 0.450000

name = Payload Deck
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 12.770090
Thermal Mass = 5.400000
Diameter/Width = 0.450000
Length = 0.500000

name = Telescope
quantity = 1
parent = 2
materialID = 5
type = Cylinder
Aero Mass = 5.860000
Thermal Mass = 5.860000
Diameter/Width = 0.300000
Length = 0.478000

name = Camera
quantity = 1
parent = 2
materialID = -2
type = Box
Aero Mass = 0.319000
Thermal Mass = 0.319000
Diameter/Width = 0.045000
Length = 0.045000
Height = 0.039000

name = Star Tracker
quantity = 2
parent = 2
materialID = 5
type = Cylinder
Aero Mass = 0.158000
Thermal Mass = 0.158000
Diameter/Width = 0.100000
Length = 0.120000

name = IMU
quantity = 2
parent = 2
materialID = 8
type = Box
Aero Mass = 0.055000
Thermal Mass = 0.055000
Diameter/Width = 0.038600
Length = 0.044800
Height = 0.021500

name = Magnetometer 1
quantity = 1
parent = 2
materialID = 8
type = Box
Aero Mass = 0.080090
Thermal Mass = 0.080090
Diameter/Width = 0.043000
Length = 0.099170
Height = 0.017000

name = DC-DC Converter 1
quantity = 5
parent = 2
materialID = 8
type = Box
Aero Mass = 0.137000
Thermal Mass = 0.137000
Diameter/Width = 0.077500
Length = 0.083000
Height = 0.018230

name = Antenna Deck
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.873090
Thermal Mass = 0.363000
Diameter/Width = 0.450000
Length = 0.500000

name = X-Band Antenna
quantity = 1
parent = 9
materialID = 8
type = Flat Plate
Aero Mass = 0.300000
Thermal Mass = 0.300000
Diameter/Width = 0.103403
Length = 0.149936

name = S-Band Antenna
quantity = 1
parent = 9
materialID = 8
type = Flat Plate
Aero Mass = 0.120000
Thermal Mass = 0.120000
Diameter/Width = 0.083820
Length = 0.083820

name = Magnetometer 2
quantity = 1
parent = 9
materialID = 8
type = Box
Aero Mass = 0.080090
Thermal Mass = 0.080090
Diameter/Width = 0.045000
Length = 0.099170
Height = 0.017000

name = Coarse Sun Sensor
quantity = 2
parent = 9
materialID = 8
type = Cylinder
Aero Mass = 0.005000
Thermal Mass = 0.005000
Diameter/Width = 0.015300
Length = 0.064000

name = Propulsion Deck
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 8.054537
Thermal Mass = 5.400000
Diameter/Width = 0.450000
Length = 0.500000

name = Tank 1
quantity = 1
parent = 14
materialID = 8
type = Cylinder
Aero Mass = 0.669000
Thermal Mass = 0.669000
Diameter/Width = 0.146800
Length = 0.265900

name = Tank 2
quantity = 1
parent = 14
materialID = 8
type = Cylinder
Aero Mass = 0.669000
Thermal Mass = 0.669000
Diameter/Width = 0.146800
Length = 0.265900

name = Thruster Head Assembly
quantity = 1
parent = 14
materialID = 8
type = Box
Aero Mass = 0.521000
Thermal Mass = 0.521000
Diameter/Width = 0.139130
Length = 0.164490
Height = 0.100140

name = Coarse Sun Sensor
quantity = 4
parent = 14
materialID = 8
type = Cylinder
Aero Mass = 0.005000
Thermal Mass = 0.005000
Diameter/Width = 0.015300
Length = 0.064000

name = Fine Sun Sensor
quantity = 1
parent = 14
materialID = 5
type = Box
Aero Mass = 0.035000
Thermal Mass = 0.035000
Diameter/Width = 0.032000
Length = 0.034000
Height = 0.021000

name = UHF Whip Antenna
quantity = 1
parent = 14
materialID = 19
type = Cylinder
Aero Mass = 0.000460
Thermal Mass = 0.000460
Diameter/Width = 0.000645
Length = 0.158750

name = UHF Whip Cover
quantity = 1
parent = 14
materialID = 23
type = Cylinder
Aero Mass = 0.006477
Thermal Mass = 0.006477
Diameter/Width = 0.004750
Length = 0.203200

name = Tank Bracket
quantity = 4
parent = 14
materialID = 65
type = Box
Aero Mass = 0.053000
Thermal Mass = 0.053000
Diameter/Width = 0.055920
Length = 0.121500
Height = 0.045730

name = MLB Upper Half
quantity = 1
parent = 14
materialID = 9
type = Box
Aero Mass = 0.521600
Thermal Mass = 0.521600
Diameter/Width = 0.344340
Length = 0.344340
Height = 0.026100

name = Avionics Deck
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 17.864399
Thermal Mass = 5.400000
Diameter/Width = 0.450000
Length = 0.500000

name = PCU
quantity = 1
parent = 24
materialID = 5
type = Box
Aero Mass = 0.990000
Thermal Mass = 0.990000
Diameter/Width = 0.147000
Length = 0.202000
Height = 0.050000

name = Battery
quantity = 2
parent = 24
materialID = -1
type = Box
Aero Mass = 1.600000
Thermal Mass = 1.600000
Diameter/Width = 0.098000
Length = 0.176000
Height = 0.096000

name = DC-DC Converter 2
quantity = 3
parent = 24
materialID = 8
type = Box
Aero Mass = 0.137000
Thermal Mass = 0.137000
Diameter/Width = 0.077500
Length = 0.083000
Height = 0.018230

name = X-Band Radio
quantity = 1
parent = 24
materialID = 8
type = Box
Aero Mass = 1.000000
Thermal Mass = 1.000000
Diameter/Width = 0.115000
Length = 0.160000
Height = 0.046000

name = S-Band Radio
quantity = 1
parent = 24
materialID = 8
type = Box
Aero Mass = 0.200000
Thermal Mass = 0.200000
Diameter/Width = 0.050000
Length = 0.135000
Height = 0.025000

name = UHF Radio
quantity = 1
parent = 24
materialID = 8
type = Box
Aero Mass = 0.141700
Thermal Mass = 0.141700

Diameter/Width = 0.057150
Length = 0.082550
Height = 0.015748

name = FC
quantity = 1
parent = 24
materialID = 8
type = Box
Aero Mass = 3.980000
Thermal Mass = 3.980000
Diameter/Width = 0.121920
Length = 0.219600
Height = 0.116000

name = Reaction Wheels
quantity = 4
parent = 24
materialID = 8
type = Box
Aero Mass = 0.226000
Thermal Mass = 0.226000
Diameter/Width = 0.140000
Length = 0.140000
Height = 0.041900

name = Torque Rods
quantity = 3
parent = 24
materialID = 54
type = Cylinder
Aero Mass = 0.420000
Thermal Mass = 0.420000
Diameter/Width = 0.022220
Length = 0.227000

name = GPS Receiver
quantity = 1
parent = 24
materialID = 8
type = Box
Aero Mass = 0.240700
Thermal Mass = 0.240700
Diameter/Width = 0.079400
Length = 0.092100
Height = 0.025100

name = DC-DC Converter 3
quantity = 1
parent = 24
materialID = 8
type = Box

Aero Mass = 0.137000
Thermal Mass = 0.137000
Diameter/Width = 0.077500
Length = 0.083000
Height = 0.018230

name = Solar Array
quantity = 1
parent = 1
materialID = 24
type = Flat Plate
Aero Mass = 2.855000
Thermal Mass = 2.855000
Diameter/Width = 0.665000
Length = 0.845000

name = Radiating Side Panel
quantity = 2
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.700000
Thermal Mass = 0.700000
Diameter/Width = 0.380000
Length = 0.431000

name = Support Strut
quantity = 2
parent = 1
materialID = 8
type = Box
Aero Mass = 0.144000
Thermal Mass = 0.144000
Diameter/Width = 0.150000
Length = 0.582000
Height = 0.020000

name = Front Side Panel
quantity = 1
parent = 1
materialID = 8
type = Flat Plate
Aero Mass = 0.700000
Thermal Mass = 0.700000
Diameter/Width = 0.380000
Length = 0.480000

**************OUTPUT****
Item Number = 1

name = Global-4
Demise Altitude = 77.993824

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Payload Deck
Demise Altitude = 67.115456
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Telescope
Demise Altitude = 0.000000
Debris Casualty Area = 0.957818
Impact Kinetic Energy = 2348.565186

****
name = Camera
Demise Altitude = 67.115456
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Star Tracker
Demise Altitude = 65.363691
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = IMU
Demise Altitude = 63.755644
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Magnetometer 1
Demise Altitude = 64.400390
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = DC-DC Converter 1
Demise Altitude = 62.070245
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Antenna Deck
Demise Altitude = 77.186238
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = X-Band Antenna
Demise Altitude = 70.000488
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = S-Band Antenna
Demise Altitude = 71.607386
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Magnetometer 2
Demise Altitude = 74.098441
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Coarse Sun Sensor
Demise Altitude = 76.683043
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Propulsion Deck
Demise Altitude = 64.939163
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Tank 1
Demise Altitude = 58.162186
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Tank 2
Demise Altitude = 58.162186
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Thruster Head Assembly
Demise Altitude = 0.000000
Debris Casualty Area = 0.548016
Impact Kinetic Energy = 122.851974

****
name = Coarse Sun Sensor
Demise Altitude = 64.315616
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Fine Sun Sensor
Demise Altitude = 58.694725
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = UHF Whip Antenna
Demise Altitude = 64.827491
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = UHF Whip Cover
Demise Altitude = 64.474280
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Tank Bracket
Demise Altitude = 0.000000
Debris Casualty Area = 1.841898
Impact Kinetic Energy = 5.603826

****
name = MLB Upper Half
Demise Altitude = 0.000000
Debris Casualty Area = 0.726832
Impact Kinetic Energy = 44.850822

****
name = Avionics Deck
Demise Altitude = 67.843011
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = PCU
Demise Altitude = 54.559678
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Battery
Demise Altitude = 67.843011
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = DC-DC Converter 2
Demise Altitude = 64.073003

Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = X-Band Radio
Demise Altitude = 55.989608
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = S-Band Radio
Demise Altitude = 64.227691
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = UHF Radio
Demise Altitude = 63.593499
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = FC
Demise Altitude = 45.256295
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Reaction Wheels
Demise Altitude = 64.600612
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Torque Rods
Demise Altitude = 57.078577
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = GPS Receiver
Demise Altitude = 62.363499
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = DC-DC Converter 3
Demise Altitude = 64.073003
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

name = Solar Array
Demise Altitude = 0.000000
Debris Casualty Area = 1.821465
Impact Kinetic Energy = 236.710159

****
name = Radiating Side Panel
Demise Altitude = 75.396285
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Support Strut
Demise Altitude = 77.429097
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****
name = Front Side Panel
Demise Altitude = 75.679121
Debris Casualty Area = 0.000000
Impact Kinetic Energy = 0.000000

****

============== End of Requirement 4.7-1 ==============
11 29 2018; 22:18:33PM Science and Engineering - Apogee/Perigee History for a Given Orbit

INPUT

Perigee Altitude = 475.000000 (km)
Apogee Altitude = 475.000000 (km)
Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)
Argument of Perigee = 0.000000 (deg)
Mean Anomaly = 0.000000 (deg)
Area-To-Mass Ratio = 0.005900 (m^2/kg)
Start Year = 2019.250000 (yr)
Integration Time = 23.000000 (yr)

OUTPUT

Plot
11 29 2018; 22:18:57PM Science and Engineering - Orbit Lifetime/Dwell Time

INPUT

Start Year = 2019.250000 (yr)
Perigee Altitude = 475.000000 (km)
Apogee Altitude = 475.000000 (km)
Inclination = 45.000000 (deg)
RAAN = 0.000000 (deg)

Argument of Perigee = 0.000000 (deg)
Area-To-Mass Ratio = 0.005900 (m^2/kg)

OUTPUT

Orbital Lifetime from Startyr = 4.041068 (yr)
Time Spent in LEO during Lifetime = 4.041068 (yr)
Last year of Propagation = 2023 (yr)
Returned Error Message: Object reentered

ODAR Section 8: Assessment for Tether Missions

Not applicable. There are no tethers on the Global satellites.

END of ODAR for Globa1-4